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DESCRIPTION

BRAKING DEVICE FOR AN ELEVATOR

Technical Field

[0001] The present invention relates to a braking device for an elevator.

Background Art

[0002] Conventionally, there has been a braking device for an elevator, which keeps a braking state with a pressing force of a spring, and keeps a releasing state with a magnetic force of a permanent magnet. The braking state is switched to the releasing state by energizing an electromagnet coil with a DC current to generate a strong magnetic field in the same direction as that of the permanent magnet, thereby attracting an armature against the force of the spring. After the attraction is completed, the armature can be kept in an attracted state owing to a magnetic force of the permanent magnet even if the DC current is interrupted. The releasing state is switched to the braking state by energizing the coil with a DC current generating a magnetic force that cancels the magnetic force of the permanent magnet (see Patent Document 1, for example).

[0003] Patent Document 1: Japanese Utility Model Application Laid-open No. Sho 57-128

Disclosure of the Invention

Problem to be solved by the Invention

[0004] In the conventional braking device for an elevator as described above, it is required to compress the spring with a force even larger than a force corresponding to a braking force, for switching between the braking state to the releasing state. Therefore, a current that flows through the coil cannot help increasing.

[0005] An object of the present invention is to provide a braking device for an elevator with smaller energy required for braking and releasing a brake.

Means for solving the Problem

[0006] The present invention provides a braking device for an elevator, characterized by including: a movable plunger; a braking mechanism that is connected to one end of the movable plunger and is switched between a braking state and a releasing state due to a movement in an axial direction of the movable plunger; a first drive mechanism using a mechanical or magnetic force, for reversing the movable plunger in a middle of a movable range in the axial direction for switching between the braking state and the releasing state to press and hold the movable plunger to a braking side or a releasing side; and a second drive mechanism using an electromagnetic force, driving the movable plunger to a reversion position in the middle of the movable range from the braking side or the releasing side against a pressing force of the first drive mechanism in order to switch between the braking state and the release state.

Effect of the Invention

[0007] According to the present invention, a braking device for an elevator with smaller energy required for braking and releasing a brake of an elevator can be provided.

Brief Description of the Drawings

[0008] [Fig. 1] A view showing a configuration of a braking device for an elevator according to Embodiment 1 of the present invention.

[Fig. 2] A diagram schematically showing a relationship between a travel distance of a movable plunger and a force in a direction represented by an arrow A of a belleville spring in the braking device of Fig. 1.

[Fig. 3] A view showing a releasing state of the braking device of Fig. 1.

[Fig. 4] A diagram showing exemplary power supplies for a releasing coil and a braking coil of the braking device for an elevator according to the present invention.

[Fig. 5] A view showing a configuration of a braking device for an elevator according to Embodiment 2 of the present invention.

[Fig. 6] A diagram schematically showing a relationship between a travel distance of a movable plunger and a magnetic force in a direction represented by an arrow A of a permanent magnet in the braking device of Fig. 5.

[Fig. 7] A view showing a releasing state of the braking device of Fig. 5.

[Fig. 8] A view showing a configuration of a braking device for an elevator according to Embodiment 3 of the present invention.

[Fig. 9] A view showing a releasing state of the braking device of Fig. 8.

[Fig. 10] A view showing a configuration of a braking device for an elevator according to Embodiment 4 of the present invention.

[Fig. 11] A view showing a releasing state of the braking device of Fig. 10.

[Fig. 12] A view showing a configuration of a braking device for an elevator according to Embodiment 5 of the present invention.

[Fig. 13] A diagram schematically showing a relationship between a travel distance of a movable iron core, and a permanent magnet force, a braking spring force, and a biasing spring force.

Best Mode for carrying out the Invention

[0009] According to the present invention, a switching between a braking state and a releasing state of a braking device is performed by reversion of a belleville spring, and reversion of a magnetic circuit using a magnet and a movable iron core, and both the states are kept by the same mechanism. Furthermore, a switching device for switching between the braking state and the releasing state of the braking device is composed of a non-magnetic repulsion plate and two coils placed on both sides so as to be opposed to each other, and utilizes a repulsion force obtained owing to an eddy current which is generated in the repulsion plate when a pulse current flows

through one of the coils. Furthermore, the switching device for switching between the braking state and the releasing state of the braking device is composed of a movable iron core and two coils placed on both sides so as to be opposed to each other, and a yoke constituting a magnetic path, and utilizes an attraction force with respect to the movable iron core generated when one of the coils is excited by causing a current to flow therethrough.

[0010] Consequently, in the conventional braking device, it is necessary to attract an armature against a spring force generating a braking force in shifting the braking state to the releasing state. Therefore, a large force is required over an entire travel stroke of the armature, making it necessary to use large energy. According to the braking device of the present invention, the switching between the releasing state and the braking state of the braking device is performed with the reversion of the same mechanism. Therefore, in order to switch a state, only energy for reversing the mechanism (i.e. about half of the stroke) is required, whereby small energy suffices. Furthermore, the braking device of the present invention is characterized in that the braking device can follow an operation even if the operation speed of the braking device during braking is increased, and a grasp position is shifted from the center. Hereinafter, the present invention will be described in accordance with each embodiment.

[0011] Embodiment 1

Fig. 1 shows a configuration of a braking device for an elevator according to Embodiment 1 of the present invention. An outer edge of a belleville spring 10a is supported on a fixing portion by a support portion 10b. Furthermore, an inner edge (center portion) of the belleville spring is fixed onto a movable plunger 5 by a support portion 10c. One end of the movable plunger 5 is connected to one end of a link 4 via a support shaft 6, and the link 4 can rotate about the support shaft 6. The other end of the link 4 is connected to an end of an arm 2 via the support shaft 7 so as to be rotatable with respect to a support shaft 7. The arm 2 is rotatably fixed to a fixing shaft 3. At a tip end of the arm 2, a sliding member 1 that comes into direct contact with a disk, a rail (not shown), or the like is mounted. At the other end of the movable plunger 5, a drive portion 20 of the movable plunger is placed. The drive portion 20 is composed of a repulsion plate 20a made of a non-magnetic material such as aluminum or copper, a releasing coil 20b placed so as to be opposed to the repulsion plate 20a, and a braking coil 20c. The repulsion plate 20a is fixed to the movable plunger 5, and the releasing coil 20b and the braking coil 20c are placed on opposite sides (so as to be opposed) to each other with the repulsion plate 20a interposed therebetween. Note that, a braking mechanism is constituted of members denoted by reference numerals 1 to 4, 6, and 7, a first drive mechanism is constituted of members denoted by reference numerals 10a-10c, and a second drive

mechanism is constituted of members denoted by reference numeral 20.

[0012] Next, an operation will be described. Fig. 1 shows a state in which a disk or a rail is held between the sliding members 1, and a braking force is exhibited. At this time, the belleville spring 10a generates a spring force in a direction represented by an arrow A with respect to the support portion 10c. As a result, the movable plunger 5 also receives a force in the direction represented by the arrow A, and the support shafts 7 of the links 4 attempt to open toward right and left sides. The arms 2 generate a force in a direction of closing the sliding members 1 with the fixing shaft 3 being a pivot, whereby a sufficient braking force can be obtained.

[0013] When a large current is allowed to flow momentarily through the releasing coil 20b from the state of Fig. 1, an eddy current is generated in the repulsion plate 20a so as to cancel a magnetic field generated in a coil. The magnetic field of the releasing coil 20b and the magnetic field generated by the eddy current in the repulsion plate 20a repel each other, whereby the repulsion plate 20a receives a force in a direction represented by an arrow B. The force received by the repulsion plate 20a is larger than the force generated by the belleville spring 10a, and the movable plunger 5 starts moving in the direction represented by the arrow B. Fig. 2 schematically shows a travel distance of the movable plunger 5 at this time and the force generated by the belleville spring 10a

in the direction represented by the arrow A. A horizontal axis of Fig. 2 represents an entire travel distance 10. When the movable plunger 5 travels to a predetermined position (position where the belleville spring becomes flat), the belleville spring is reversed, and the support portion 10c travels to an arrow B side beyond the support portion 10b. The belleville spring 10a starts generating a negative force (i.e., a force in the direction represented by the arrow B) with respect to the direction represented by the arrow A (actually, a force in an opposite direction is generated beyond a neutral position). Consequently, even if a current is not flowing through the releasing coil 20b, as shown in Fig. 3, the movable plunger 5 travels in the direction represented by the arrow B with the force of the belleville spring 10a, the support shafts 7 travel so as to close from the right and left sides due to the function of the links 4, the arms 2 rotate in a direction of opening the sliding members 1 with the fixing shaft 3 being the pivot, the braking force is released, and the releasing state is kept by the spring force of the belleville spring 10a. At this time, although the movable range of the movable plunger 5 is determined by the spring force of the belleville spring 10a, it is preferable to provide a stopper 8 limiting the movable range at the fixing portion 10c or the repulsion plate 20a so as to prevent a collision between the coils 20b, 20c and the repulsion plate 20a.

[0014] The releasing state may be switched to the braking state

by causing a large current to momentarily flow through the braking coil 20c. The operation principle is the same as that of the switching from the braking state to the releasing state except that the direction of a force to be generated becomes opposite. Therefore, the detailed description thereof will be omitted.

[0015] A power supply apparatus for causing the above-mentioned large current to momentarily flow through the coils 20b and 20c can be obtained by closing a switch 31 and opening a switch 32 to discharge a charge, which is previously charged in a capacitor 33 from a DC power supply 30 by opening the switch 31 and the closing the switch 32, as shown in Fig. 4. At this time, a diode 34 protects the capacitor 33 from a reverse flow of the current, and concurrently, prevents the fluctuation in electromagnetic characteristics to enhance energy efficiency. Furthermore, the switching between the braking state and the releasing state is performed by connecting the switch 32 to the releasing coil 20b or by connecting to the braking coil 20c. According to this system, the switching between the braking state and the releasing state can be performed while the capacitor is charged even in the event of a power failure, and a safety as an emergency braking device can be ensured. A switching power supply at this time supplies electric power by an emergency battery (not shown) for operating the elevator to a nearest floor in the event of a power failure, which is originally provided in the elevator. The electric power required for switching is very

weak, so the electric power required for operating the elevator to the nearest floor in the event of a power failure is not influenced even if the battery is not enforced for switching. Furthermore, it is also possible to increase the capacity of the emergency battery to charge the capacitor.

[0016] With the construction described above, according to the present system, the brake releasing state and braking state are both caused by the reversion of the belleville spring, so energy required for switching the state is that of merely reversing the mechanism, that is, about half of a stroke), whereby small energy suffices, while the conventional brake needs large energy because of a need for attracting an armature against a spring force generating a braking force in shifting the braking state to the releasing state. Furthermore, the repulsion force in a magnetic field caused by an eddy current is used as a drive force for switching between the braking state and the releasing state of the brake, so the brake operation is fast.

[0017] Embodiment 2

Fig. 5 shows a configuration of a braking device for an elevator according to Embodiment 2 of the present invention. A magnet spring 40 is composed of a permanent magnet 40a, a movable iron core 40b that is fixed to the movable plunger 5 and moves integrally therewith, and a yoke 40c placed so as to surround them. The other configuration is the same as that of Embodiment 1. Note that, a braking mechanism

is constituted of members denoted by reference numerals 1 to 4, 6, and 7, a first drive mechanism is constituted of members denoted by reference numeral 40, and a second drive mechanism is constituted of members denoted by reference numeral 20.

[0018] Next, an operation will be described. Fig. 5 shows a state in which a disk or a rail is held between the sliding members 1, and a braking force is exhibited. At this time, the movable iron core 40b is pressed in a direction represented by an arrow A due to a magnetic flux generated by the permanent magnet 40a in a direction represented by an arrow C. As a result, the movable plunger 5 also receives a force in the direction represented by the arrow A, and the support shafts 7 of the links 4 attempt to open toward the right and left sides. The arms 2 generate a force in a direction of closing the sliding members 1 with the fixing shaft 3 being a pivot, whereby a sufficient braking force can be obtained.

[0019] When a large current is allowed to flow momentarily through the releasing coil 20b from the state of Fig. 5, an eddy current is generated in the repulsion plate 20a so as to cancel the magnetic field generated in the coil. The magnetic field of the releasing coil 20b and the magnetic field generated by the eddy current in the repulsion plate 20a repel each other, whereby the repulsion plate 20a receives a force in a direction represented by an arrow B. The force received by the repulsion plate is larger than the magnetic force generated by the permanent magnet 40a, and the movable

plunger 5 starts moving in the direction represented by the arrow B. Fig. 6 schematically shows a travel distance of the movable plunger 5 at this time and the magnetic force generated by the permanent magnet in the direction represented by the arrow A. A horizontal axis of Fig. 6 shows an entire travel distance 10. When the movable plunger 5 travels to a predetermined position (intermediate position of a stroke), the magnetic field in a direction represented by an arrow C of Fig. 5 and the magnetic field in a direction represented by an arrow D shown in Fig. 7 are balanced, and the movable iron core 40b travels with inertia without being influenced by a force. When the movable plunger 5 travels further, a magnetic path is formed in the direction represented by the arrow D as shown in Fig. 7, and a negative force (i.e., a force in the direction represented by the arrow B) starts to be generated in the direction represented by the arrow A. Therefore, even if a current is not allowed to flow through the releasing coil, as shown in Fig. 7, the movable plunger 5 travels with the magnetic force in the direction represented by the arrow B, the support shafts 7 travel so as to close from the right and left sides due to the function of the links 4, the arms 2 rotate in the direction of opening the sliding members 1 with the fixing shaft 3 being the pivot, the braking force is released, and the releasing state is kept with the magnetic force. At this time, it is preferable to provide the stopper 8 limiting a movable range at upper and lower limits of

the movable range of the movable iron core 40b or the repulsion plate 20a so as to prevent the contact between the movable iron core 40b and the yoke 40c, and the contact between the coils 20b, 20c and the repulsion plate 20a.

[0020] The releasing state may be switched to the braking state by causing a large current to momentarily flow through the braking coil 20c. The operation principle is the same as that of the switching from the braking state to the releasing state except that the direction of a force to be generated becomes opposite. Therefore, the detailed description thereof will be omitted.

[0021] With the construction described above, according to the present system, the brake releasing state and braking state are both caused by the reversion of the magnetic field generated by the movement of the iron core, so energy required for switching the state is that of merely reversing the magnetic field, whereby small energy suffices, while the conventional brake needs large energy because of a need for attracting an armature against a spring force generating a braking force in shifting the braking state to the releasing state. Furthermore, the repulsion force in a magnetic field caused by an eddy current is used as a drive force for switching between the braking state and the releasing state of the brake, so the brake operation is fast.

[0022] Embodiment 3

Fig. 8 shows a configuration of a braking device for an elevator

according to Embodiment 3 of the present invention. An electromagnetic attracting device 50 is composed of a permanent magnet 50a, a movable iron core 50b that is fixed to the movable plunger 5 and travels integrally therewith, a braking coil 51a and a releasing coil 51b placed on opposite sides (so as to be opposed) on both sides of the permanent magnet 50a, and a yoke 50c placed so as to surround coils 51a, 51b, the permanent magnet 50a, and the movable iron core 50b. The other configuration is the same as that of Embodiment 1. Note that, a braking mechanism is constituted of members denoted by reference numerals 1 to 4, 6, and 7, a first drive mechanism is constituted of members denoted by reference numeral 50, and a second drive mechanism is constituted of members denoted by reference numerals 51a and 51b.

[0023] Next, an operation will be described. Fig. 8 shows a state in which a disk or a rail is held between the sliding members 1, and a braking force is exhibited. At this time, both the braking coil 51a and the releasing coil 51b are not excited, and the movable iron core 50b is pressed in the direction represented by the arrow A due to a magnetic flux generated by the permanent magnet 50a in the direction represented by the arrow C. As a result, the movable plunger 5 also receives the force in the direction represented by the arrow A, and the support shaft 7 of the link 4 attempts to open toward right and left sides. The arm 2 generates a force in the direction of closing the sliding member 1 with the fixing shaft

3 being a pivot, whereby a sufficient braking force can be obtained.

[0024] When the releasing coil 51b is excited by causing a current to flow therethrough from the state of Fig. 8, a magnetic flux in a direction represented by an arrow E is formed to generate a force of pulling the movable iron core 50b back to the direction represented by the arrow B. If the current flowing through the coil is set to be sufficiently strong, the magnetic field generated by the coil becomes larger than the magnetic field generated by the permanent magnet, and the movable iron core 50b starts traveling in the direction represented by the arrow B. When the movable plunger travels to a predetermined position (intermediate position of a stroke), the movable iron core 50b travels with inertia without being influenced by a magnetic force. When the movable plunger 5 travels further, the magnetic field generated by the permanent magnet in the direction represented by the arrow C of Fig. 8 and the magnetic field generated by the permanent magnet in a direction represented by an arrow D show in Fig. 9 are balanced, and the movable iron core 50b travels with inertia without being influenced by a force from the permanent magnet 50a. A magnetic path is formed in the direction represented by the arrow D as shown in Fig. 9, and a negative force (i.e., a force in the direction represented by the arrow B) starts to be generated with respect to the arrow A. Therefore, even if a current is not caused to flow through the releasing coil 51b, as shown in Fig. 9, the movable plunger 5 travels in the direction represented

by the arrow B with the magnetic force generated by the permanent magnet 50a, the support shafts 7 travel so as to close from the right and left sides due to the function of the links 4, the arms 2 rotate in the direction of opening the sliding members 1 with the fixing shaft 3 being a pivot, the braking force is released, and the releasing state is kept with the magnetic force. At this time, it is preferable to provide the stopper 8 for limiting a movable range of the movable iron core 50b at upper and lower limits of the movable range so as to prevent the contact between the movable iron core 50b and the yoke 50c.

[0025] The releasing state may be switched to the braking state by causing a current to flow through the braking coil 51a to exciting the braking coil 51a. The operation principle is the same as that of the switching from the braking state to the releasing state except that the direction of a force to be generated becomes opposite. Therefore, the detailed description thereof will be omitted.

[0026] With the construction described above, according to the present system, the brake releasing state and braking state are both caused by the reversion of the magnetic field generated by the movement of the iron core, so energy required for switching the state is that of merely reversing the mechanism, whereby small energy suffices, while the conventional brake needs large energy because of a need for attracting an armature against a spring force generating a braking force in shifting the braking state to the

releasing state. Furthermore, the repulsion force in a magnetic field caused by an eddy current is used as a drive force for switching between the braking state and the releasing state of the brake, so the brake operation is fast.

[0027] Embodiment 4

Fig. 10 shows a configuration of a braking device for an elevator according to Embodiment 4 of the present invention. An electromagnetic attracting device 60 is composed of a movable iron core 60a that is fixed to the movable plunger 5 and moves integrally therewith, a braking coil 61a and a releasing coil 61b placed so as to be opposed to each other with the movable iron core 60a interposed therebetween, and a yoke 60b placed so as to form a magnetic path surrounding the coils 61a, 61b, and the movable iron core 60a. The other configuration is the same as that of Embodiment 1. Note that, a braking mechanism is constituted of members denoted by reference numerals 1 to 4, 6, and 7, a first drive mechanism is constituted of members denoted by reference numerals 10a-10c, and a second drive mechanism is constituted of members denoted by reference numerals 60, 61a, and 61b.

[0028] Next, an operation will be described. Fig. 10 shows a state in which a disk or a rail are held between the sliding members 1, and a braking force is exhibited. At this time, the braking coil 61a and the releasing coil 61b both are not excited, and the movable iron core 60a is pressed in the direction represented by the arrow

A due to a repulsion force of the belleville spring 10a. As a result, the movable plunger 5 also receives the force in the direction represented by the arrow A, and the support shafts 7 of the links 4 attempt to open toward the right and left sides. The arms 2 generate a force in the direction of closing the sliding members 1 with the fixing shaft 3 being a pivot, whereby a sufficient braking force can be obtained.

[0029] When the releasing coil 61b is excited by causing a current to flow therethrough from the braking state of Fig. 10, a magnetic field in a direction represented by an arrow F is generated, and a force of pulling the movable iron core 60a back to the direction represented by the arrow B is generated. If the current flowing through the coil is set to be sufficiently strong, the attraction force acting on the movable iron core 60a becomes larger than the repulsion force of the belleville spring 10a, and the movable iron core 60a starts traveling in the direction represented by the arrow B. When the movable plunger travels to a predetermined position (a position where the belleville spring 10a becomes flat), the belleville spring is reverted, and the support portion 10c travels to the arrow B side beyond the support portion 10b. Then, the belleville spring starts generating a negative force (i.e., a force in the direction represented by the arrow B) with respect to the direction represented by the arrow A. Therefore, even if a current is not allowed to flow through the releasing coil 61b, the movable

plunger 5 travels in the direction represented by the arrow B with the force of the belleville spring, as shown in Fig. 11, the support shafts 7 travel so as to close from the right and left sides due to the function of the links 4, the arms 2 rotate in the direction of opening the sliding members 1 with the fixing shaft 3 being a pivot, the braking force is released, and the releasing state is kept with the spring force of the belleville spring. At this time, it is preferable to provide the stopper 8 for limiting a movable range of the movable iron core 60b at upper and lower limits of the movable range so as to prevent the contact between the movable iron core 60a and the yoke 60b.

[0030] The releasing state may be switched to the braking state by causing a current to flow through the braking coil 61a to excite the braking coil 61a. The operation principle is the same as that of the switching from the braking state to the releasing state except that the direction of a force to be generated becomes opposite. Therefore, the detailed description thereof will be omitted.

[0031] With the construction described above, according to the present system, the brake releasing state and braking state are both caused by the reversion of the belleville spring, so energy required for switching the state is that of merely reversing the mechanism, that is, about half of a stroke), whereby small energy suffices, while the conventional brake needs large energy because of a need for attracting an armature against a spring force generating

a braking force in shifting the braking state to the releasing state. Furthermore, the repulsion force in a magnetic field caused by an eddy current is used as a drive force for switching between the braking state and the releasing state of the brake, so the brake operation is fast.

[0032] Embodiment 5

Fig. 12 shows a configuration of a braking device for an elevator according to Embodiment 5 of the present invention. A first spring structure 701 composed of a spring frame 71, a braking spring 72, and a spring bearing 73 is configured between the movable plunger 5 and the link 4. The spring frame 71 is composed of a top plate 71a supporting the braking spring 72 that is a compression spring, an adjusting bolt 71c for adjusting a compression amount of the spring, a bottom plate 71b threaded so as to be screwed on the adjusting bolt 71c, and a stopper nut 71d screwed on the adjusting bolt 71c so as not to change the position of the bottom plate. The spring bearing 73 supporting one end of the braking spring is attached to the spring frame 71 so that the spring bearing 73 moves along the adjusting bolt 71c. An end of an axis portion 73a, extending downward, of the spring bearing 73, is connected rotatably to the movable plunger 5 via the support shaft 6. Therefore, even if the electromagnetic attracting device 50 is operated and the support shaft 6 moves in the axial direction under a condition that a rail or disk position (i.e., a holding position) is shifted from the

center position between the sliding members 1, and a position of the support shaft 70 is shifted toward the right or left, the position can be followed while the distance between the support shaft 6 and the support shaft 70 is changed.

[0033] The electromagnetic attracting device 50 is composed of a movable iron core 50b to which movable plungers 5 and 74 placed coaxially on opposite sides (braking side and releasing side) in the axial direction are fixed so as to move integrally, a permanent magnet 50a provided around the movable iron core 50b so as to extend in parallel with the axial direction of the movable plunger, a braking coil 51a, a releasing coil 51b placed on the braking side and the releasing side (upper and lower portions in the figure) of the permanent magnet 50a so as to be opposed to each other, and a yoke 50c placed so as to surround the coils 51a, 51b, the permanent magnet 50a, and the movable iron core 50b.

[0034] The movable plunger 74 protrudes from the movable iron core 50b to a side opposite to the braking mechanism, and an adjusting spring bearing 75 is mounted at a tip end of the movable plunger 74. The adjusting spring bearing 75 and the movable plunger 74 are threaded so as to be screwed with each other, so the positional adjustment of the adjusting spring bearing 75 can be performed with respect to the movable plunger 74. A biasing spring 76 that is a compression spring is sandwiched between the adjusting spring bearing 75 and a fixing spring bearing 77, and always generates

a force in the direction represented by the arrow A with respect to the movable iron core 50b. The adjusting spring bearing 75, the biasing spring 76, and the fixing spring bearing 77 constitute a second spring structure 702.

[0035] In the above-mentioned configuration, the fixing shaft 3, the yoke 50c, and the fixing spring bearing 77 are fixed to a fixing portion of a brake base, a cage frame, or the like. The other configuration is the same as that in the above-mentioned embodiments. Note that, a braking mechanism is constituted of members denoted by reference numerals 1 to 4, 7, and 70, a first drive mechanism is constituted of members denoted by reference numeral 50, and a second drive mechanism is constituted of members denoted by reference numerals 51a and 51b.

[0036] Next, an operation will be described. Fig. 12 shows a state in which a disk or a rail is held between the sliding members 1, and a braking force is exhibited. It is assumed that a gap formed between the spring bearing 73 and the bottom plate 71b is δ. At this time, the braking coil 51a and the releasing coil 51b both are not excited, and the movable iron core 50b is pressed in the direction represented by the arrow A by the magnetic flux in the direction represented by the arrow C generated by the permanent magnet 50a. As a result, the spring bearing 73 also receives a force in the direction represented by the arrow A, and imparts a force in the direction of compressing the braking spring 72. At this time,

in order for the movable iron core 50b to be held by the yoke 50c, and to obtain a sufficient braking force, the combined force of the permanent magnet 50a and the biasing spring 76 must be set to be larger than the force generated by the braking spring 72, as shown in Fig. 13. The sliding member 1 holds a rail or a disk, and cannot move in the direction of narrowing the gap further. Therefore, the position of the support shaft 70 is not changed, and the force by which the braking spring 72 is compressed is transmitted to the sliding members 1 via the top plate 71a, the links 4, and the arms 2, whereby a sufficient braking force can be obtained.

[0037] When the releasing coil 51b is excited by causing a current to flow therethrough from the state of Fig. 12, a magnetic flux is formed in the direction represented by the arrow E, and a force of pulling the movable iron core 50b back to the direction represented by the arrow B is generated. If the current flowing through the coil is set to be sufficiently strong, the force given to the movable iron core 50b by the magnetic field induced to the coil becomes larger than the combined force generated by the permanent magnet 50a, the braking spring 72, and the biasing spring 76, and the movable iron core 50b starts traveling in the direction represented by the arrow B. To be more specific, the combined force generated by the releasing coil 51b and the braking spring 72 becomes larger than the combined force generated by the permanent magnet 50a and the biasing spring 76, whereby the movable iron core 50b travels in

the direction represented by the arrow B.

[0038] Until the movable plunger reaches a predetermined position (position at which the gap δ of Fig. 13 is 0) in the middle of a stroke, the combined force generated by the permanent magnet 50a, the braking spring 72, and the biasing spring 76 acts in the direction represented by the arrow A. However, when the movable plunger travels beyond the predetermined position, the spring bearing 73 comes into contact with the bottom plate 71b and moves integrally with the spring frame 71, and the sliding members 1 leave the rail or the disk due to the functions of the links 4 and the arms 2, whereby the braking force is released. At this time, the force given to the movable iron core 50b by the permanent magnet 50a is reversed in the direction represented by the arrow B. Therefore, even if a current is not caused to flow through the releasing coil 51b, the movable iron core 51b is pressed to the arrow B side, and the releasing state is held by the magnetic force of the permanent magnet 50a. At this time, it is preferable to provide the stopper 8 limiting the movable range of the movable iron core 50b at upper and lower limits of the movable range so as to prevent the contact between the movable iron core 50b and the yoke 50c.

[0039] The releasing state may be switched to the braking state by causing a current to flow through the braking coil 51a to excite the braking coil 51a. At this time, the force of the braking spring 72, which presses the movable iron core 50b in the direction

represented by the arrow B, does not function until the position of $\delta = 0$. Therefore, the first motion of the movable iron core 50b becomes fast, which can speed up the braking operation. The operation principle is the same as that of the switching from the braking state to the releasing state except that the force to be generated becomes opposite to return to the braking state. Therefore, the detailed description thereof will be omitted.

[0040] With the construction described above, according to the present system, the combined force generated by the braking spring 72, the biasing spring 76, and the permanent magnet 50a given to the movable iron core 50b is reversed in the middle of a stroke, so energy required for switching the state is that of merely reversing the mechanism (i.e., the one until the middle of the stroke), whereby small energy suffices, while the conventional brake needs large energy because of a need for attracting an armature against a spring force generating a braking force in shifting the braking state to the releasing state.

[0041] Furthermore, the braking spring 72 is configured so as to start acting from the middle of the stroke from the releasing state to the braking state. Therefore, the force required to be generated by the braking coil 51a for initially moving the movable iron core 50b is that of merely the difference between the force generated by the permanent magnet 50a and the force of the biasing spring 76, whereby the speed of the operation during braking of a brake

can be increased.